12   FLIGHT GUIDANCE SYSTEM INTEGRATION

Throughout the preceding sections of the document, flight guidance systems and functions have been considered as being separate and distinct from other systems and functions on the aircraft. It is recognized that in complex aircraft designs, the flight guidance functions are closely integrated with other avionics functions, and that the physical integration of these systems, may have a bearing on how airplane level safety is assessed. The following paragraphs provide guidance on the likely FGS system integration issues found in more complex aircraft system designs, and the interfaces which should be considered within the bounds of demonstrating the intended function, performance and safety of the FGS.

12.1   System Integration Issues

Integration of other aircraft systems with the FGS has the potential of reducing the independence of failure effects and partitioning between functions. This is particularly the case where hardware and software resources are shared by different systems and functions (e.g., aircraft data highway and Integrated Modular Avionics (IMA) architectures). In addition to considering the reliability and integrity aspects of the FGS as a separate system, it may be necessary to address the effects of FGS failures with respect to fault propagation, detection, and isolation within other systems. The overall effect on the aircraft of a combination of individual system failure conditions occurring as a result of a common or cascade failure, may be more severe than the individual system effect. For example, failure conditions classified under §/JAR 25.1309 as Minor or Major by themselves may have Hazardous effects at the aircraft level, when considered in combination. With regard to isolation of failures, and particularly combination failures, the ability of the alerting system to provide clear and unambiguous information to the flight crew, becomes of significant importance. (See also Section 13, Safety Assessment.)

Complex and highly integrated avionics issues present greater risk for development error. With non-traditional human-machine interfaces, there is also the potential for operational flight crew errors. Moreover, integration of systems may result in a greater likelihood of undesirable and unintended effects.

Within the FGS, where credit is taken for shared resources or partitioning schemes, these should be justified and documented within the System Safety Analysis. When considering the functional failures of the system, where such partitioning schemes can not be shown to provide the necessary isolation, possible combination failure modes should be taken into account. An example of this type of failure would be multi-axis active failures, where the control algorithms for more than one axis are hosted on a single processing element. Further, the functional integration of control functions such as control surface trimming, yaw channel, and stability augmentation, while not strictly FGS, should be considered.

12.2   Functional Interfaces

In its simplest form, the FGS may be considered as interfacing with sensors that provide the necessary inputs to enable computation of its various functions. Typically, these sensors will include air and inertial data, engine control, and navigation sensors such as ILS, VOR, and DME. In the case of engine control, a feedback loop may also be provided. The FGS may also be considered as providing inner loop closure to outer loop commands. The most common interface is with the FMS, which provides targets for lateral and vertical navigation in the form of steering orders.

In demonstrating the intended function and performance of both the FGS and systems providing outer loop commands, the applicant needs to address potential inconsistencies between limits of the two (e.g., with basic FGS pitch and bank angle limits). Failure to address these points can result in discontinuities, mode switching, and reversions, leading to erroneous navigation and other possible safety issues (e.g., buffet margin at high altitude). Similar issues arise in the inner loop, across the functional interface between FGS and flight controls. In fly-by-wire aircraft, the loss of synchronization between the two can result in mode anomalies and autopilot disengagement.

The applicant should demonstrate the intended function and performance of the FGS across all possible functional interfaces. The alerting system should also be assessed to ensure that accurate and adequate information is provided to the flight crew when dealing with failures across functional interfaces.